REMARKS

Claim 5 has been cancelled. Claims 2-4, 6-9, and 12-14 have been amended. Claims 15-20 have been added. Claims 1-4 and 6-20 are now pending.

No new matter has been added. Support for the amended claims and support for the new claims can be found in the specification and claims as originally filed.

Applicant respectfully requests reconsideration of the action mailed September 11, 2002, in view of the foregoing amendment and these remarks.

RESPONSE TO CLAIM OBJECTIONS

Claims 7 and 8 are objected to because of informalities. Claims 7 and 8 have been amended, and the noted deficiencies have been corrected. Applicant respectfully requests the Examiner withdraw the objections on Claims 7 and 8.

RESPONSE TO REJECTIONS ON CLAIM 1

Claim 1 was rejected as anticipated by U.S. Patent No. 6,002,512 ("Bergmann"). Applicant respectfully traverses the rejection.

Claim 1 is directed to a four-port loop optical circulator that includes a first, a second, a third, and a fourth optical port. Claim 1 also includes a plurality of optical components "for guiding a beam received from said first port to project from said second port, for guiding a beam received from said second port to project from said third port, for guiding a beam received from said third port to project from said fourth port." The plurality of optical components is also "for guiding a beam received from said fourth port to project from said first port."

Bergmann shows a four-port circulator that includes a first (A), a second (B), a third (C), and a fourth optical port (D). Bergmann also shows a plurality of optical components "for guiding a beam received from said first port to project from said second port, for guiding a beam received from said second port to project from said third port, for guiding a beam received from said third port to project from said fourth port" (column 2, lines 13-24, and column 4, lines 36-39).

Bergmann, however, does not show that the plurality of optical components is also "for guiding a beam received from said fourth port to project from said first port." More specifically,

Bergmann states that "a signal applied as an input to port D would be deflected further down when traversing through device 20 and either be lost or coupled into a lower port" (column 4, lines 36-39), but fails to show that the lower port is port A. Bergmann does not show that a signal applied as an input to a fourth port exits at the first port. Thus, Bergmann's circulator is not a loop optical circulator.

Therefore, claim 1 is allowable.

RESPONSE TO REJECTIONS ON CLAIMS 2-4 AND 6-8

Claims 2-4 were rejected as anticipated by Bergmann. Claims 6-8 were rejected as obvious over Bergmann in view of U.S. Patent No. 5,878,176 ("Cheng"). Applicant respectfully traverses the rejection.

Claim 2 is directed to a four-port loop optical circulator that includes a first, a second, a third, and a fourth optical port. The four-port loop optical circulator also includes a walk-off crystal and a vertical displacement means for shifting an optical path. The vertical displacement means is coupled to the walk-off crystal "for guiding a beam received from said fourth port to project from said first port."

Bergmann shows a first walk-off device (12), a second walk-off device (20), and a third walk-off device (28). Cheng shows a three-port device that includes a polarization beam splitter (14) and a right angle prism (13). Bergmann and Cheng, either alone or in combination, does not teach or suggest a vertical displacement means coupled with a walk-off crystal in such a way "for guiding a beam received from said fourth port to project from said first port."

Bergmann shows that a beam received from a fourth port "would...either be lost or coupled into a lower port" (column 4, lines 36-39), but fails to show that the lower port is port A. Bergmann does not show any devices "for guiding a beam received from said fourth port to project from said first port."

The Examiner argues that Cheng shows a polarization beam splitter (14) and a right angle prism (13) for "extending of the input/output capability of an optical circulator" (page 5 of the official action). Applicant respectfully submits that Cheng does not show any devices for "extending of the input/output capability of an optical circulator" in such a way to construct a loop optical circulator. More specifically, Cheng does not show an optical loop circulator having

a first, a second, a third, and a fourth optical port and including a vertical displacement means coupled with a walk-off crystal in such a way "for guiding a beam received from said fourth port to project from said first port."

Thus, the combination of Bergmann and Cheng does not teach or suggest a vertical displacement means coupled with a walk-off crystal "for guiding a beam received from said fourth port to project from said first port" as recited in claim 2.

Therefore, claim 2 is allowable. Claims 3, 4, and 6-8 depend from claim 2 and are allowable for at least the same reason.

RESPONSE TO REJECTIONS ON CLAIMS 9-14

Claims 9, 11, and 12 were rejected as anticipated by U.S. Patent No. 6,226,115 ("Shirasaki"). Claim 10 was rejected as obvious over Shirasaki in view of Bergmann. Claim 14 was rejected as obvious over Shirasaki in view of U.S. Patent No. 6,282,336 ("Riza"). Claim 13 was rejected as obvious over U.S. Patent No. 5,034,950 ("Jackel") in view of Riza. Applicant respectfully traverses the rejection.

Claim 9 is directed to a switchable optical loop circulator and includes a loop optical circulator. The loop optical circulator has N ports each being labeled as port K with K chosen consecutively from 1 to N. The loop optical circulator is "operable to guide a beam received from port K to port K+1 if K is less than N and operable to guide a beam received from port N to port 1". N is an integer that is at least three, and K is an integer that is at least 1.

For an example case that N=4, claim 9 includes a loop optical circulator that has 4 ports. The loop optical circulator is operable to guide a beam received from port 1 to port 2, to guide a beam received from port 2 to port 3, and to guide a beam received from port 3 to port 4. The loop optical circulator is also operable to guide a beam received from port 4 to port 1.

Shirasaki shows a circulator that has four ports. Port 1, port 2, port 3, and port 4 are respectively corresponding to fibers, 200, 256, 252, and 226. Shirasaki shows a circulator that is operable to guide a beam received from port 1 to port 2, to guide a beam received from port 2 to port 3, and to guide a beam received from port 3 to port 4 (column 3, lines 51 and 52). Shirasaki, however, fails to show that the circulator is also operable to guide a beam received from port 4 to port 1. That is, Shirasaki does not show a loop optical circulator that is "operable to guide a

beam received from port K to port K+1 if K is less than N and operable to guide a beam received from port N to port 1."

Bergmann shows a four-port circulator. Bergmann's circulator, however, is not a loop optical circulator. Riza shows a 2x2 fiber-optic switch and not a loop optical circulator. Jackel shows a laser application system that includes an amplifier and two rotating polarization devices. Bergmann, Riza, or Jackel, either alone or in combination, does not show a loop optical circulator that is "operable to guide a beam received from port K to port K+1 if K is less than N and operable to guide a beam received from port N to port 1."

Therefore, the combination of Shirasaki, Bergmann, Riza, and Jackel fails to show a loop optical circulator as recited in claim 9. For at least this reason, claim 9 is allowable. Claims 10-14 depend from claim 9 and are allowable for at least the same reason.

Attached is a marked-up version of the changes being made by the current amendment.

Applicant asks that all claims be allowed. Enclosed is a $174 check for excess claim fees. Please apply any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

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Version with markings to show changes made

In the Specification:

Paragraph beginning on page 3, line 21, has been amended as follows:

[Fig. 4 shows] Figs. 4A and 4B show the function of rhomb prism and DOVE prism that exchange positions of a pair of light beam.

Paragraph beginning on page 6, line 35, has been amended as follows:

As the incident light, received from port 3, passes through a collimator comprises a dual fiber capillary lA, and a GRIN lens 2A, a collimated beam is generated. The collimated beam is projected to a birefringent crystal 3A; the beam is divided into two mutually orthogonal components, namely ordinary and extraordinary components. These two components are spatially separated to pass through half wave plates 4A and 4B respectively. The half wave plates 4A and 4B are applied to rotate the state of polarization of the beam to mirror position against the optical axis of the plates. The arrangement of the optical axis of the two half wave plates 4A and 4B causes the state of polarization of the o-component and the e-component to have a forty-five degree tilt toward the first quadrant as that shown in Fig. 2A. A Faraday rotator 5A rotates these two beam components to have same state of polarization represented by two horizontal bars in the small circles. The prism 6A corrects the tilt angle of the dual fiber collimator to generate beam components parallel to the walk off crystal. The walk off crystal 7 is employed that serves a special function to maintain the incident optical path without optical-path displacement for beams with a horizontal polarization represented by the horizontal bars. After passing through the walk-off crystal 7, the beam components, as shown in Fig. 3A, are projected through a polarization beam splitter (PBS) 8 maintaining a same optical path. The PBS transmits light with SOP in incident plane to pass through and reflects the light with SOP perpendicular to the plane. The SOP of the light in the optical path of 3 to 4 marked by horizontal bar is perpendicular to the incident plane. In order to transmit the light passing

through the PBS, the half wave plate (HWP) 9A which axis is 45-degree orientation is used to rotate the SOP with 90-degree rotation to allow the light to pass through. After the PBS, the HWP 9B changes the SOP back to the original SOP. Then the beam components are projected to a prism 6B to generate a small tilt angle and ready to project to an output port of a dual fiber collimator. The state of polarization of these two beam components when passing through the Faraday rotator 5B are rotated to a negative forty-five degree tilted toward the second quadrant. These states of polarization of these two beam components after passing through the half-wave plates 11A and 11B are rotated to be mutually orthogonal again. These two beam components are recombined through the second birefringent crystal 3B as an output beam for projecting to output port 4 with a small tilt angle to match the small tilt angle of the optical fiber of port two incorporated m a dual fiber collimator.

In the Claims:

Claim 5 has been cancelled.

Claims 2-4, 6-9, and 12-14 have been amended as follows:

2. (Amended) [The] <u>A</u> four-port loop optical circulator [of claim 1 wherein] <u>comprising</u>:

<u>a first, a second, a third and a fourth optical port for receiving optical beam therein;</u>

<u>a plurality of optical components for guiding a beam received from said first port to project from said second port, for guiding a beam received from said second port to project from said third port, for guiding a beam received from said third port to project from said fourth port, and for guiding a beam received from said fourth port to project from said first port; and wherein</u> said plurality of optical components [further] includes

a walk-off crystal for generating a vertical optical path displacement for a vertical polarized optical beam and for passing a horizontally polarized optical beam therethrough maintaining a same optical path[.],

a vertical displacement means for shifting an optical path along a vertical direction with a predefined vertical displacement for an optical beam transmitted with a particular polarization, and

wherein said vertical displacement means is coupled to said walk-off crystal for guiding a beam received from said fourth port to project from said first port.

3. (Amended) The four-port loop optical circulator of claim 2 wherein:

said plurality of optical components further includes a first birefringent crystal disposed on a [left hand-side] left-hand side of said walk-off crystal for generating a first ordinary beam and a first extra-ordinary beam and a second birefringent crystal disposed on a right-hand side of said walk-off crystal for generating a second ordinary beam and a second extra-ordinary beam.

4. (Amended) The four-port loop optical circulator of claim 2 wherein:

said plurality of optical components further includes a first polarization rotation means disposed on said [left hand-side] left-hand side of said walk-off crystal for generating a first state of polarization (SOP) for said first ordinary beam and said first extra-ordinary beam to project to said walk-off crystal and a second polarization rotation means disposed on said right-hand side of said walk-off crystal for generating a second SOP for said second ordinary beam and said second extra-ordinary beam to project to said walk-off crystal wherein said first SOP is orthogonal to said second SOP.

6. (Amended) The four-port loop optical circulator of claim [5] 2 wherein:

said vertical displacement means further comprising a polarized beam splitter for reflecting an optical beam with said particular polarization substantially along a vertical direction for generating said predefined vertical displacement.

7. (Amended) The four-port loop optical circulator of claim [7] 6wherein:

said vertical displacement means further comprising a right angle prism disposed at said predefined vertical displacement away from said polarized beam splitter, said right angle prism reflecting said optical beam with said particular polarization projected from said polarized beam splitter for transmitting said optical beam with said particular polarization substantially along a horizontal direction.

8. (Amended) The four-port loop optical circulator of claim 7 wherein:

said vertical displacement means further comprising a first set of half wave plates for changing a state of polarization (SOP) of a beam by 90 degrees toward a first angular direction to a polarized beam splitter (PBS)-incident SOP to allow a beam to pass through or reflected from said PBS depending on said PBS-incident SOP then another set of half wave plates to rotate said SOP of said beam by 90 degrees toward a second angular direction opposite to said first angular direction.

9. (Amended) A switchable optical loop circulator comprising:

a loop optical circulator having N ports each being labeled as port K with K chosen consecutively from 1 to N, the loop optical circulator operable to guide a beam received from port K to port K+1 if K is less than N and operable to guide a beam received from port N to port 1, where N is an integer that is at least three and K is an integer that is at least 1; and

[a loop optical circulator and at least] an optical switching means disposed in an optical path of the loop circulator for switching optical transmission paths of said loop optical circulator.

12. (Amended) The switching means of claim 9 wherein:

said switching means further comprising an electrically controlled half wave plate composed of liquid crystals.

13. (Amended) The switching means of claim 9 wherein:

said switching means further comprising an electrically controlled in/out rhomb prism.

14. (Amended) The switching means of claim 9 wherein:

said switching means further comprising an electrically controlled in/out DOVE prism.

In the Abstract:

[This invention discloses a] A four-port loop optical circulator[. The circulator] includes a first, a second, a third and a fourth optical ports for receiving optical beam therein. The circulator further includes a plurality of optical components[for guiding a beam received from the first port to project from the second port, for guiding a beam received from the second port to project from the third port. The optical components are further used for guiding a beam received from the third port to project from the fourth port, and for guiding a beam received from the fourth port to project from the first port]. The optical components include a walk-off crystal for generating a vertical optical path displacement for a vertical polarized optical beam and for passing a horizontally polarized optical beam therethrough maintaining a same optical path. The optical components also include a vertical displacement device for shifting an optical path along a vertical direction with a predefined vertical displacement for an optical beam transmitted with a particular polarization. The vertical displacement device is coupled to the walk-off crystal for guiding a beam received from the fourth port to project from the first port. [In a preferred embodiment, the plurality of optical components further include a walk-off crystal for generating a vertical optical path displacement for a vertical polarized optical beam and for passing a horizontally polarized optical beam therethrough maintaining a same optical path. In another preferred embodiment, the invention discloses a switchable optical loop circulator that includes a loop optical circulator and an optical polarization switching means disposed in an optical path of the loop circulator for switching optical transmission paths of the loop optical circulator. In a preferred embodiment, the optical switching device includes a set of latched Faraday rotators surrounded by an electromagnetic pulse means for controlling a rotation direction of the latched Faraday rotators. In a particular embodiment, the optical polarization switching means further includes electrically controlled half wave plates composed of electro-optic materials or liquid crystals. In another preferred embodiment, the optical switching device further includes an electrically controlled in/out rhomb prism or DOVE prism.]